Biotech Corn and Soybeans:
Changing Markets and the Government's Role

I. Introduction

In this paper we examine market-driven product differentiation in the markets for biotech and non-biotech corn and soybeans[1] and discuss areas where government involvement may be warranted. We describe the potential benefits and costs of government involvement in facilitating market differentiation and explore a number of policy options. Though we focus on differentiation in the markets for biotech and non-biotech corn and soybeans, many aspects of the analysis are relevant to differentiation in any market for value-enhanced commodities.

We find that the private markets for corn and soybeans have shown flexibility in reacting to recent shifts in consumer preferences. Both the domestic and international marketing systems have begun to differentiate markets for biotech and non- biotech commodities and products. Domestic producers are responding to the opportunities arising with differentiated markets: some are benefiting through the lower production costs associated with first-generation biotech varieties; while others are tailoring their production to benefit from the emerging markets (and price premia) for non- biotech products. However, a number of concerns are arising, primarily with respect to how the market mechanism is allocating the benefits and costs of biotech and non-biotech product differentiation. The first set of concerns involves the distribution of the economic risks associated with non- biotech production. The second set involves the distribution of the economic risks associated with biotech production. The third involves the distribution of the costs and benefits arising after the introduction of first-generation biotech varieties and the subsequent demand for non-biotech products.

We discuss ten different types of options for government to facilitate market differentiation for biotech and non-biotech commodities: prohibition against non-biotech labeling, consumer education programs, voluntary labeling, government-set tolerance levels for non-biotech commodities, government-established testing standards, storage programs, enhanced market information, changes in farm support programs, mandatory labeling of biotech food products, and increased public research and development. An important way the government can support market flexibility in the face of diversification and differentiation is to provide information on market statistics that mirror the development of new varieties and differentiated markets. For biotech and non- biotech commodities, information on price, acreage and potential markets can help farmers and other market participants make informed decisions (although proliferation of products and contracting systems may make it difficult for the government to provide accurate statistics on all varieties). Another important role for government with respect to agricultural biotechnology is to ensure that the government's regulatory capacity, and therefore, its credibility with the public, continues to advance along with advances in biotechnology. For this reason, further investments in public research and development, or reallocation of the research and development portfolio, may be warranted.

This background paper begins by describing the U.S. corn and soybean marketing system. It then examines evidence on the extent of consumer demand for non-biotech products both within the U.S. and abroad; describes the market's response to the emerging demand for non-biotech commodities and products to date; and explores

[1] Agricultural biotechnology is a collection of scientific techniques, including conventional hybridization, that are used to create, improve, or modify plants, animals, and microorganisms. Recently, the term biotechnology has been used to refer more specifically to products that have been genetically engineered (biochemical manipulation of genes or DNA). This is the meaning adopted here.

the potential for "market failure" in market-driven differentiation of biotech and non- biotech commodities and products. The last section reviews areas where government involvement in market differentiation may be warranted and weighs some options for intervention.

II. Background

Corn and soybeans have become focal points for the discussion of market differentiation for biotech and non-biotech commodities in the United States for a number of reasons. First, they are the two most important field crops in the U.S. in terms of volume and cash receipts. Corn heads the list with a total projected production of 9.4 billion bushels in 1999 and a value of approximately $17.9 billion. Soybeans follow with projected total production of 2.6 billion bushels in 1999, and a value of about $12.5 billion. Second, these two crops are the primary biotech crops used in the production of food or feed. It is estimated that in 1999, roughly 35 percent of planted acres in the seven key corn states went to genetically modified corn and 55 percent of planted acres in the eight key soybean states went to genetically modified soybeans. Third, corn and soybeans are prevalent throughout the food supply. Whether through direct consumption, processed foods or meat consumption, consumers eat a wide variety of food items containing or, in the case of meat, fed with corn or soybeans.

The ability of the corn and soybean markets to successfully differentiate depends on the flexibility of the marketing system and the ability of each component in the system to segregate non- biotech and biotech commodities and products. The primary components in the corn and soybean marketing system are farmers, handlers (dealers), processors, and exporters. Figure 1 illustrates the flows in the marketing system. After harvest, farmers typically sell their crop to country elevators who store grain and deliver larger volumes to terminal elevators. From the terminal elevator, grain then moves either directly to the export market or to domestic processing plants where it is transformed into food and feed products.

The snap-shot view of the corn and soybean marketing system provided by Figure 1 masks both the flexibility and heterogeneity of the system. The marketing systems for corn and soybeans are developing and changing in response to two different trends in American agriculture. On the one hand, economies of scale are leading to fewer and larger farms and greater concentration and integration among grain handlers, processors and exporters. On the other hand, small segments of the corn and soybean markets are moving away from the marketing of general bulk commodities. These segments are becoming increasingly differentiated, with farmers, handlers and processors specializing in commodities with high-valued attributes. Value-enhanced corn encompasses high-oil, white corn, hard-endosperm, and waxy varieties. Value-enhanced soybeans include clear hilum and high-oil varieties. These value-enhanced products, though still a small segment of the market, are indicative of the ability of the grain marketing system to supply differentiated quality characteristics.

The introduction of first-generation biotech varieties (those with input traits) and the subsequent demand for non- biotech commodities and products feeds into both of the market trends outlined above. The supply-expanding capability of first-generation biotech varieties is likely to reinforce the trend toward fewer and larger farms. Though early adopters of first-generation technologies reap the benefits of lower production costs, later adopters face a supply-shift price effect and, if they lag too far behind, are squeezed financially by the lower selling price dictated by a competitive market and the relatively high production costs associated with their outmoded production technology. This phenomenon reinforces the growth of larger farms and bulk production (it is an example of the standard "treadmill" phenomenon in which farmers have incentive to continuously adopt

new technologies and expand capacity). At the same time, the demand for non- biotech commodities and products fits into the second market trend. Indeed, the demand for non- biotech crops is just an extension of the trend in demand for more tightly refined quality standards – a trend that is bound to grow with increased availability of specialty crops (including eventual introduction of second-generation biotech varieties – those with output traits).

III. Consumer Demand for Non-Biotech Products

In recent months, the demand for corn and soybeans has shown signs of splintering, with a small segment of consumers preferring non- biotech products. The strength of non-biotech demand, both current and potential, will help determine the desirability of widespread product segregation and differentiation in the markets for corn and soybeans. It will also influence the rate at which differentiation occurs and ultimately, the rates at which new technologies are adopted and product innovation occurs.

Domestic Demand for Non-Biotech Products

The domestic market is the primary market for U.S. corn and soybeans. Roughly 80 percent of total corn production (not including beginning stocks) is used domestically: either fed to livestock on farms where it is produced, shipped to feed manufacturers, or shipped to wet and dry corn millers. About 15 percent of corn production is wet milled. Two byproducts of this process are corn gluten feeds and corn gluten meal, both of which are important protein supplements to livestock feed. Less than 40 percent of corn gluten and meal were fed to domestic livestock and poultry in 1997/98. Like corn, the majority of the U.S. soybean crop is used domestically. Roughly two percent of U.S. soybeans are used for direct domestic feed use, 3 percent for seed use, about 30 percent are exported, and roughly 50 percent are crushed. The majority of the U.S. soybean crush is used domestically, but meal and oil produced by crushing soybeans in the United States are also exported.

The importance of the domestic market for corn and soybeans makes the question of domestic consumer attitudes toward biotechnology all the more critical. If domestic consumers begin to demand non-biotech products, then the market would seem to have no other choice but to segregate biotech from non-biotech. However, it is difficult to gauge current U.S. consumer sentiment regarding the use of biotechnology in food, and even more difficult to predict potential shifts in consumer attitudes. Economists rely on two sources of evidence to measure consumer attitudes. The first and most reliable source is actual market transactions in which informed consumers pay for things they want. The second source is survey data. These two sources of information suggest that American consumers are generally unconcerned about the use of biotechnology in food, and recent media coverage of environmental or European concerns over biotech has had little impact on most Americans' attitudes to date.

The broadest sort of market evidence available to researchers is the simple observation that in the United States biotech ingredients are common in a wide range of products that consumers routinely purchase (from pudding to bacon bits). The fact that consumers are willing to pay for these goods would seem to suggest that either most Americans believe that biotech foods are safe, or that most are unaware of the widespread use of these ingredients. Evidence from one of the first and most widely discussed applications of biotechnology in the United States, bovine growth hormone (bGH), suggests that most Americans are willing to accept the use of genetic engineering in their food. In a study conducted in 1998, ERS researchers were unable to detect any effect of bGH introduction on monthly per capita milk consumption for 12 milk "marketing order" regions from December 1978 through September 1996.

A Gallup Poll survey conducted September 23-26, 1999 found that only 10 percent of those surveyed had heard a "great deal" about the issue of genetic modification for producing food and medicine, another 40 percent said they had heard or read "some," while half indicated they had heard "little to nothing" about it. Earlier surveys reveal that this level of awareness of biotech issues is relatively high for American consumers. Throughout the 1990's, surveys found that only 30 to 40 percent of consumers were aware of the use of biotechnology in food production – and maybe even more importantly, not only did most consumers lack knowledge about biotechnology, most were unaware of traditional food production techniques in general. The increased awareness of genetically engineered food revealed in the September Gallup Poll survey probably reflects the media coverage of the Dolly cloning in 1997 and, more recently, the extensive coverage of agricultural biotechnology.

Results of the Gallup Poll survey and other similar surveys suggest that most Americans are not worried about the safety of biotechnology in food production. Fifty-three percent of the respondents in the recent Gallup Poll survey felt that biotechnology in food production did not pose a health hazard to consumers, 20 percent were unsure and 27 percent believed that biotechnology posed a serious health hazard. Fifty-one percent said they supported the use of biotechnology in food production while 41 percent were opposed. These results suggest that domestic demand for non- biotech food will remain low. However, this conclusion may be premature. Surveys of Japanese consumers conducted throughout the 1990's yielded similar results. A survey of Japanese consumers (January 1998) indicated that only 40 percent were aware that biotech products were being sold (despite increased media coverage since 1995). And, as in the United States, Japanese consumers displayed little awareness of traditional food production techniques, let alone biotechnology. However, despite an apparent lack of concern over biotechnology, by the end of September 1999, some Japanese consumers had convinced a number of Japanese firms to offer non- biotech products (most notably, beer and baby food).

As in Japan, studies of general consumer attitudes in the United States may not be good indicators of where the market is heading. Those who conduct surveys cannot know for certain if respondents have thought carefully or responded truthfully. In addition, markets react to a number of factors besides the number of potential consumers. In particular, the intensity of consumer preferences and concern for firm reputation may influence marketing decisions. A more telling result of the recent Gallop Poll survey may be that though slightly more than 50 percent of Americans moderately or strongly support use of biotech in food production, those who strongly oppose the technology outnumber those who strongly support it by almost two to one. Overall, 9 percent of Americans strongly supported biotech methods while16 percent strongly opposed them (42 percent moderately supported and 25 percent moderately opposed).

Foreign Demand for Non-Biotech Products

European consumers have long been wary of biotech foods. Their concerns have been echoed recently by some consumers in a number of other countries, most notably Japan. As a result of some consumer attitudes, some foreign governments and food manufacturers have taken a number of steps toward segregation of the biotech and non-biotech markets. Some food manufacturers in a few countries have moved to provide non- biotech products: several major food chains in the EU have indicated they will stop selling biotech foods under their house-brand names in some EU countries; some Japanese brewers have announced they will stop using biotech corn to produce their beer; Japan's largest manufacturer of soy protein food announced that it will stop using biotech soybeans; several major fast-food chains said they will not use biotech foods in their products in the

United Kingdom; and a major Mexican corn flour miller has said it will stop buying biotech corn. In addition, the European Union, Japan, Brazil, Korea, Australia and New Zealand all have taken steps to establish labeling programs for biotech foods.

Though government and industry reaction to consumer demand in foreign markets has been impressive, the impact on the U.S. corn and soybean markets could ultimately be quite limited. This is because those foreign markets that are imposing or considering restrictions on biotech imports (bans, no new approvals, or labeling requirements) currently represent a relatively small share of the U.S. market. For corn, direct overseas sales represent 20 percent of total production, with sales to the European Union just a small part of total exports: even in the best years (the early 90's), exports to the European Union represented only about 5 percent of U.S. corn exports. Sales to Japan are approximately 25 percent of U.S. corn exports. Approximately a third of U.S. soybeans were directly exported in 1998/99, with about 10 percent of total production exported to the European Union over the past 3 years. Of the 830 million bushels of U.S. soybeans exported in fiscal 1998/99, the EU share comprised about 25 percent, down from 40 percent or higher in the early 1990's. Japan accounts for roughly 15 percent of U.S. raw soybean exports. Japan represents a specialty market for U.S. soybean producers, and U.S. producers have made a number of adjustments to supply this market with high-quality soybeans such as food-grade bean varieties with high protein, large seeds and clear or light hilum. Shipments of "IOM" soybeans (high quality food grade soybeans grown in the Midwest, including *I*ndiana, *O*hio, and *M*ichigan) to Japan currently account for about 500,000 tons a year.

The importance of soybean meal and corn gluten for animal feed means that U.S. markets would be impacted if foreign markets impose restrictions on biotech products that extend to processed livestock and poultry feed. In 1997/98, the U.S. corn wet-milling industry processed 15 percent of the U.S. corn crop to produce about 9.0 million metric tons of corn gluten feed and meal (mostly corn gluten feed), of which over 60 percent was exported. The EU is the most important export market of these wet-milling byproducts, accounting for more than 85 percent of total exports. In fact, the value of corn gluten feed and meal exported to the EU in 1997/98 ($454.8 million) far exceeded the value of corn exports to that market ($15.1 million). For soybeans, though much of the U.S. soybean crush is used domestically, trade is still important. In 1998/99, 20 percent and 13 percent of U.S. soybean meal and oil supply were exported. In 1998/99, major U.S. soybean meal importers were the EU, China, the Philippines, Japan, Egypt, Canada, and Venezuela. For U.S. soybean oil, major export destinations were China, India, South Korea, and Mexico.

If foreign market demand for non-biotech commodities spreads to include strict regulations on processed food labeling, then the impact on U.S. producers could be more substantial. Through 1997, U.S. exports of processed food and beverages, including beer, wine and soft drinks, grew faster than exports of raw agricultural commodities, accounting for over half of total agricultural exports. In 1997, processed food exports totaled $31.3 billion, with the Japanese market accounting for 20.6 percent ($6.4 billion) of the U.S.'s processed food export market, followed by Canada ($5.0 billion, 16.1-percent share), Mexico ($2.4 billion, 7.7-percent share), South Korea ($1.5 billion, 4.9-percent share) and Hong Kong ($1.3 billion, 3.7-percent share). Collectively, the EU countries represented $4.6 billion, a 14.6-percent share. In 1997, the five largest processed food exports were meatpacking, soybean oil milling (soybean oil and meal), poultry processing, fresh or frozen fish and seafood and wet corn milling (oil, syrup and starch).

A substantial portion of U.S. owned food processors has probably already incorporated foreign demand into their production strategies. Over 80 percent of processed food sold abroad by U.S. firms originated from U.S.-owned

plants in foreign countries. In 1997, sales from U.S.-owned food processing plants abroad totaled about $134 billion--over four times the value of U.S.-based processed food exports. There are a variety of reasons for locating plants overseas, including escaping import tariffs, reducing transportation costs, or even the desire to be more responsive to local markets and local cultures. When a firm makes sales through foreign subsidiaries, by definition it already has some capacity to differentiate host-country manufactured products from U.S.-manufactured products. Establishing host-country manufacturing capacity indicates the firm has made a long-term commitment to filling specificities of host-country demand. Thus, biotech labeling and product diversification may not be as much a burden for subsidiaries established through foreign direct investment as for manufacturers exporting from locations in the U.S. In fact, these production lines may already be exclusively non- biotech. The impact on U.S.-based firms servicing both the domestic and foreign markets could be more problematic. In order to warrant the expense of developing two separate product lines or product reformulation, the benefits of marketing two different products (with two different sets of input costs) would need to outweigh the costs of segregation. If not, these processors would probably decide to specialize and service only one market.

Overall, current levels of foreign demand for non-biotech commodities represent only a small share of the U.S. market. However, if restrictions are expanded to include animal feed and strict labeling requirements for processed foods, the impact on the United States has potential to be much more substantial. Foreign shifts in demand may also have a more substantial impact on the U.S. market than expected because of the degree of concentration among U.S. exporters. If key exporters decide to segregate then the impact on the domestic market will be a large, abrupt shift in demand as opposed to the small continuous shifts that describe final consumption demand.

IV. Market Reaction

How has the U.S. market for corn and soybeans reacted to consumer demand for non- biotech products and commodities? Two types of reactions are possible: the market could react through increased domestic segregation of biotech and non- biotech commodities and products (differentiation at the domestic level); or, the market could react through a readjustment of trade flows (differentiation at the international level). To date, the U.S. market has exhibited some of both reactions, albeit at low rates so far.

Domestic Market Response

Though domestic consumer demand for non-biotech products remains largely undetermined, and the magnitude of foreign demand appears rather small when compared with total U.S. production, this demand (or potential demand) is triggering some changes in the domestic marketing system for corn and soybeans. In 1999, a number of events signaled some movement toward market differentiation in the United States. In April, major U.S. processors (ADM and A.E. Staley) announced that they would not purchase corn that has not been approved by the EU. In July, Gerber and Heinz said they would stop using biotech ingredients in baby food; and in August, ADM recommended that producers segregate biotech from non- biotech varieties and EU-unapproved from EU-approved varieties, though they withdrew this recommendation in February 2000. In early 2000, Frito-Lay Inc. announced it would use only non-biotech corn in its snack foods.

To supply the emerging market for non-biotech products, some grain handlers have begun to segregate biotech from non-biotech corn and soybeans. A survey by Sparks Companies, Inc. conducted in the summer of 1999, estimated that 11 percent of Midwest grain elevators segregated for non-biotech corn and 8 percent for non-biotech soybeans. At that time, several industry representatives expressed the view that a larger proportion of elevators segregated non-biotech crops, while other industry analysts marveled at the fact that any segregation had been achieved. A February 2000 survey commissioned by Pioneer Hi-Bred and conducted by Farm Progress Companies estimated that more elevators will be segregating in the fall of 2000. This survey of nearly 1,200 elevators estimated that 24 percent of elevators will segregate biotech corn and 20 percent will segregate biotech soybeans. Elevators with the most potential to successfully segregate are those that have a large volume of bin capacity and multiple pits (where grain is dropped before being moved to the storage bin)[2]. Even with this system, however, there is the potential for inadvertent co-mingling because augers and other equipment are shared and used for both biotech and non-biotech crops. Logistical problems depend on the volume of non-biotech grain entering the elevator and are far more severe during peak harvest seasons. Still, one general manager at a prominent grain-handling firm said that, if necessary, they could segregate at most of their facilities.

Of those surveyed elevators that segregated, the summer 1999 survey by Sparks Companies, Inc. found that 1 percent offered premiums for non-biotech corn and 3 percent offered premiums for non- biotech soybeans – though again, several industry representatives expressed the view that a larger proportion of elevators offered premiums. A consensus on what these premiums are or how they will behave in the future is not yet available. Independent discussions with people from the National Corn Growers Association, American Soybean Association, and various grain companies reveal that there is a large variance in the level of premiums being offered for non- biotech commodities. In 1999, Reuters reported that non-biotech price premiums ranged from 8-15 cents for corn and 10 to 30 cents for soybeans. In the fall of 1999, Bridge News reported that grain terminals located along the interior U.S. river system offered premiums of as much as 8-10 cents for a bushel of non- biotech corn and up to 15 cents for non- biotech soybeans. Robert Wisner, extension economist at Iowa State, found similar results stating that premiums for non-biotech crops were in the 10-15 cent range for corn and 5-35 cent range for soybeans. In the fall of 1999, a common range for soybean premiums seemed to be 10-15 cents (roughly a 2-3 percent premium), while corn premiums tended to fall in the 5-10 cent range (roughly a 2-6 percent premium). The February 2000 survey commissioned by Pioneer Hi-Bred and conducted by Farm Progress Companies estimated that slightly more than 1 out of 10 elevators are planning to offer a price premium for non-biotech products in the fall of 2000.

To help elevators and processors provide assurances of non- biotech purity, a number of private firms have begun to market biotech testing products. Genetically modified crops differ from their conventional counterparts by addition of one or more new genes (DNA sequences) into the plant genome. Each gene tells the plant to produce a new protein that confers a new trait. Examples are Bt, a bacterial gene that tells the plant to produce a protein that can be toxic to certain insect pests, and CP4-EPSPS, a bacterial gene for a protein that confers resistance to the Roundup herbicide. Biotech detection methods test for either the new DNA sequence or for production of the new protein. There is no one generic test for biotech products. In general, separate tests must be developed and/or optimized for each biotech trait, although protocols can be designed to test one product for the presence of several biotech traits simultaneously.

[2] The size and number of individual bins is also important. If an elevator has a large number of small bins (as opposed to a small number of large bins) it will be able to segregate more effectively. Currently there are no estimates of elevator capacity that account for the size of individual bins.

Two types of tests have been developed to detect use of biotechnology, both of which have been validated as methods for biotech detection by the Joint Research Council in the EU. In the first method, foreign DNA sequences in plant material are detected using a technique called the polymerase chain reaction (PCR). PCR is a very sensitive technique that can detect less than 0.1 percent genetically modified material in a sample (i.e., 1 bean in 1000). However, PCR tests are susceptible to errors due to contaminants, DNA breakdown, or improper implementation, and testing must be performed under rigorous laboratory conditions with appropriate controls. For these reasons, PCR is not easily adaptable for rapid on-site testing at elevators or processing plants. Currently, PCR testing of crops and processed products for the use of biotechnology is offered commercially at a cost of $200-$450 per test; the tests take 2-10 days to perform.

The second method for biotech testing is an ELISA (enzyme-linked immunosorbent assay) test that detects foreign proteins. Two types of ELISA test kits are currently available, with more being developed. The first type can be used for quantitative determination of biotech content; results can be obtained in 2 hours at a cost of up to $10.00 per sample tested. The second type, rapid dipstick tests, can give a qualitative yes/no result for biotech material in less than 20 minutes at a cost of $1.00 - $5.00 per test. The level of detection for ELISA tests will vary for each product tested (due to differing levels of foreign protein in each product) and for each kit (due to quality of the antibody). However, the manufacturers claim that the dipstick tests will reliably detect 0.1 percent biotech material for Roundup Ready soybeans and 2 percent biotech material for Bt corn. The ELISA-based test kits are being marketed to seed developers, analytical laboratories, elevators, and processors both in the United States and abroad.

In sum, the domestic market has demonstrated capacity to respond to demand for both biotech and non-biotech products although clearly the adjustment process is still underway and many farms, handlers, and processors are waiting to see how the market will evolve. Nevertheless, some processors and elevators have begun to segregate biotech from non- biotech commodities, and the technology to monitor biotech product characteristics is being developed. The corn and soybean marketing systems seem to be exhibiting a high degree of sensitivity to shifts in consumer demand. These private systems seem to be adapting to the demand for segregation.

International Trade Response

Another type of market response to changes in consumer preferences is a shift in international trade patterns. Global commodity markets are composed of many bilateral trade flows linking individual country markets. With flexible and responsive trade flows, the demand for non-biotech products could trigger changes in trade flows and patterns to accommodate supply and demand changes at the national level. There is some evidence that shifts in national preferences for non- biotech products may be one of many factors that explain recent shifts in trade flows. Other factors that explain patterns in world trade over time include the relative proximity of importers and exporters, historical trade ties, weather variability, domestic agricultural policies, and degree of price sensitivity in a market.

During the late 1990's, the EU regulatory process for biotech varieties triggered changes in trade patterns for corn. Between 1996 and 1998, the EU significantly shifted its corn purchases from U.S. sources toward Eastern European sources where non-biotech corn varieties were grown, and to Argentina, where only EU-approved varieties and non-biotech corn were grown. During the same period, U.S. corn sales increased in some other markets, and the ability to reroute trade meant that total volume of corn trade was likely little affected, although the shifts may have caused costly inconveniences and higher transportation costs. EU corn imports are typically

very small in relation to total world trade; consequently, price impacts even if EU imports had been dramatically reduced would be negligible or slight. However, this market represented an import quota to compensate trading partners for the loss of market when Spain and Portugal joined the EU. This supposedly assured market opportunity was therefore put at risk by the EU's biotech regulatory process.

In contrast to corn, soybeans provide examples of markets where trade represents larger shares of domestic production and trade flows are more concentrated. As mentioned earlier, about 30 percent of U.S. soybean exports have gone to the EU in the last 3 years and about 16 percent of U.S. exports have gone to Japan. Argentina and Brazil are the two major U.S. competitors on the global soybean market. For the EU, they supply an average 5 mmt per year in relation to an average 8 mmt per year from the United States. In fact, Argentina and Brazil have been considerably more dependent on EU markets than has the United States in the last few years, although they too have other important buyers in Asia, the middle East, Eastern Europe and non-EU Western Europe.

EU approvals of U.S. soybean varieties have not to date posed the same problem as with corn, because Roundup Ready is the only commercially grown biotech soybean variety in the U.S. and it has been approved by the EU, but consumer preferences may have begun to affect markets. EU buyers have increased purchases from Brazil, Eastern Europe and some other non-biotech suppliers and reduced purchases from the United States. There are no obvious examples of the U.S. supplying markets previously supplied by Brazil. Other likely more important reasons for changes in global markets include increased supply from Brazil and changes in domestic agricultural policy in producing and consuming countries. From 1996 to 1998, Brazil has steadily increased total trade, and from 1997 to 1998, U.S. exports fell from 26 to 20 million metric tons.

In contrast to the corn case, it would be difficult for trade shifts alone to accommodate a highly restrictive biotech policy by the EU without a substantial global price effect. This is because the EU is a large buyer on the world soybean market, and the ability of non-biotech suppliers to step in and fill this large EU demand is questionable. However, the burden of significantly reduced trade would fall on the EU too. This is because, for soybeans, the EU is relatively dependent on imports for its internal supply. Choking off trade would significantly increase internal prices paid by EU soybean buyers, who are livestock producers, food manufacturers, and ultimately consumers. It will be up to EU consumers to determine if they are willing to pay significant price premiums to realize a preference for non-biotech foods.

Changes in Japanese trade illustrate how the emergence of new marketing channels can facilitate market adjustment. Unlike the EU where most soybeans end up in animal feed, humans in Japan consume a significant amount of soybeans. To date, Japan continues to import transgenic soybeans for use in animal feed. However, the United States has also been exporting organic and non-biotech soybeans to the Japanese market, and segregation to serve the Japanese market is not a new development.

These corn and soybean trade scenarios suggest two possible outcomes of market adjustment. One is that countries could specialize as biotech or non-biotech suppliers, and as biotech or non-biotech buyers. The likelihood of this outcome is enhanced if biotech preferences take shape along national lines. Also, the impact on the U.S. corn and soybean markets could ultimately be pretty limited if foreign demand for non-biotech imports continues as it now does to represent a relatively small share of total U.S. demand. However, if foreign markets expand their restrictions on biotech products to include processed livestock and poultry feed, then clearly the impact on the U.S. market would be more substantial. A second possible outcome is for markets to evolve such

that each country supplier and each country buyer trades a mix of biotech and non-biotech commodities. For this to happen in the United States (and we do see signs of it happening), demand for non-biotech commodities must result in price premiums that cover the added costs of segregation. Marketing channels and services that facilitate the ability of sellers to differentiate and guarantee the characteristics of their products must develop. In turn, the more rapidly these channels and services evolve, the lower will be the segregation and information costs and the more efficiently buyers with diverse preferences can be served.

V. Potential Market Failures in Biotech and Non-Biotech Product Differentiation

The markets for corn and soybeans have shown signs of reacting with surprising speed to recent shifts (real or perceived) in consumer preferences and regulatory barriers. Both the domestic marketing system and international markets have begun to differentiate markets for biotech and non-biotech commodities and products. Consumer preferences or regulatory systems have provided some incentives to supply differentiated products, and some producers have responded to these incentives. The market appears to be working. However, a number of concerns are arising, primarily with respect to how the market mechanism is allocating the benefits and costs of biotech and non-biotech product differentiation. The first set of concerns involves the distribution of the economic *risks of non-biotech production*. The second set involves the distribution of *the economic risks of biotech production*. The third involves the distribution of *the costs and benefits arising after the introduction of first-generation biotech varieties and the subsequent demand for non-biotech products*. Each set of concerns is examined below.

Distribution of the Economic Risks Associated with Non-Biotech Production

The ultimate viability of a market for non- biotech commodities hinges on the ability of producers to provide credible assurances to consumers that the products they purchase are truly non-biotech. To date, the responsibility (and the liability) for these assurances seem to have fallen on the farmer. Because tests for biotech content impose costs on the marketing system (in terms of time and money), many handlers and processors are relying on farmers to establish the non-biotech status of the product. To this end, some elevators are developing contracts stating that farmers are liable in the event that grain shipments are rejected for containing biotech varieties or EU-unapproved varieties if farmers had sold their grain to the elevator as non-biotech or EU approved. (In 1999, Iowa's Attorney General's office advised farmers not to sign such a contract with grain elevators.)

Another potential source of economic risk to farmers wishing to specialize in non-biotech crops is the supply of non- biotech seeds. There is concern that in their push to promote biotech varieties, seed companies may not have produced enough non-biotech varieties to supply the market. Depending on farmer demand in the upcoming season, there could be seed shortages of either biotech or non-biotech seeds. These shortages would likely be felt more at the local than at the aggregate level. However, the ability of the seed industry to respond rapidly in the past to challenges such as poor quality of seed, or the need for new cultivars resistant to particular diseases, suggests that though these shortages may attract considerable interest, they are unlikely to be a recurrent, longer run phenomenon. All major seed companies for corn, soybeans, and cotton continue to produce and provide non-biotech varieties along with their biotech varieties.

The ability to respond to market demand for seed is not a new issue that has arisen with biotechnology, and seed companies have developed flexible supply strategies for a wide variety of seeds. At present, the supply channels for corn seed are somewhat more flexible than they are for soybeans because corn seed stores somewhat better than soybean seed and a considerable amount of corn seed is produced economically in South America during the North American winter. However, the soybean seed industry has one source of flexibility that the corn seed industry does not have. If there is demand for a particular type of soybean seed, a company could contract with farmers who are growing that variety in "clean" fields to supply seeds. This practice occurred last year when there was a bigger-than-expected demand for biotech soybeans, and presumably the same thing could happen if there were a larger-than-expected demand for non-biotech soybeans.

Another source of uncertainty, if not risk, that farmers are confronting as differentiation occurs in the corn and soybean markets is the contracting system itself. If contracting becomes prevalent in this market and the share of biotech or non-biotech commodities being bought and sold in the open market declines, open market prices will become a less representative indicator of underlying market forces. In these cases, farmers may be less able to gauge either the direction of the market or fair market prices. Unlike the case of individual production decisions where farmers determine the costs and benefits of product innovation and determine whether the innovation is worthwhile, individuals are not given the choice of whether or not to participate in the contracting system.

The flip side of the new economic risks that farmers are confronting is the compensation they are being offered to assume these risks. As mentioned previously, to encourage farmers to provide non-biotech varieties (thereby compensating for some of these additional risks and costs), elevators have begun to offer premiums for non-biotech varieties. For 1999, a common range for soybean premiums seemed to be 10-15 cents (roughly a 2-3 percent premium), while corn premiums tended to fall in the 5-10 cent range (roughly a 2-6 percent premium). Whether or not these price premiums, or any price premiums, can provide adequate incentive for farmers to continue assuming these additional risks depends on future market developments including any liability claims.

Distribution of the Economic Risks Associated with Biotech Production

Currently, most of the economic risk associated with growing and marketing biotech crops and products is due to the concern that markets for these crops and products may be unreliable. Biotech crops that were acceptable to the EU or other foreign markets at the beginning of the growing season could become unacceptable by the end of the season. Again, most of these economic risks are being borne by farmers. Seed companies have developed "growers agreements" stating that farmers are responsible for finding domestic market outlets for their crops if export markets are closed for the biotech crops they grew. Though elevators have been assisting farmers by diverting unapproved crops to domestic feedlots, feed manufacturers, or other market outlets, there is some concern that this flexibility may be curtailed by recent events such as the decisions by ADM and A.E. Staley to restrict their processing facilities to EU-approved varieties. It is worth pointing out though, that both biotech and non-biotech farmers are covered by government farm programs. Declines in farm prices, whatever the cause, are cushioned by the government's marketing loan program. Loan deficiency payments in 1998 and 1999 have been quite high compared with historical levels. LDP outlays have generally been less than $1 billion, but in calendar 1998 were estimated at $2.8 billion, and for calendar 1999, are projected at $6.6 billion. These large payments have been in response to low market prices for corn, soybeans, and other program crops. For example, in 1999, soybean prices were at their lowest levels in 23 years.

Storage problems due to segregation of biotech and non- biotech commodities could also saddle farmers with additional risks and costs. If segregation were to become more widespread, many farmers and commercial storage facilities would not have enough bins to separate varieties. In the short run, storage shortages would tend to depress prices. Grain would be stored in temporary facilities rather than in grain bins and elevators, and in some cases quality could be lost. Furthermore, moving grain in and out of temporary storage facilities and into conventional storage involves costs and handling fees, which ultimately are charged to the producers either in terms of direct charges or lower bid prices. If product differentiation leads to greater incentives for grain to move directly from farms to processors in order to reduce the costs of segregation, then there would be an increased demand for on-farm storage facilities. In either case, farmers would absorb the costs of extra segregation. Though a constraint for many farmers, the need for additional storage capacity for segregation might provide farmers with available storage an opportunity to make increased profits due to their ability to more easily supply differentiated commodities.

Again, the flip side of the new economic risks and costs farmers are facing due to biotechnology is the additional compensation they receive with biotech varieties. If the risks and costs of planting biotech varieties outweighed the benefits, farmers would presumably switch to conventional varieties. To date, the evidence on whether or not biotechnology has benefited farmers seems to be more positive than negative. However, even though survey data have been collected on the characteristics and performance of farms adopting biotech crops, it is still difficult to draw conclusions about the impact of biotech adoption on yields and input use because many factors influence crop outcome. In a simple comparison of means for three years of production (1996-98), ERS researchers found that the use of Bt corn was associated with significantly higher yields in most years for some regions of the county, while herbicide-tolerant soybeans were associated with significantly higher yields in some regions in 1997. Statistically controlling for factors other than the adoption of biotech varieties, ERS found that increases in adoption of herbicide-tolerant soybeans were associated with small increases in yields, and significant decreases in total herbicide use.

Whether or not any of the yield gains and input reductions associated with biotechnology use actually translate into increased profits for farmers depends on how much of the economic surplus they retain and how much is passed back to seed producers through seed prices and technology fees, or is passed forward to consumers through lower prices. To date it appears that farmers are retaining a good part of this surplus. Research conducted by Traxler et al. shows that in 1997, farmers retained 50 percent of the total economic surplus from Roundup Ready soybeans while domestic consumers enjoyed 8 percent (rest of world surplus was 12 percent). The gene developer (Monsanto) retained 22 percent of the surplus while the seed companies (primarily Pioneer, Asgrow, DeKalb[3], and Novartis) retained 9 percent. Various estimates of the distribution of benefits for innovations in pre-biotech hybrid crops such as corn suggest that anywhere from 50 to 75 percent of the benefits from these innovations were shared with farmers and consumers.

These results are complicated, however, by several factors. First, they are subject to the normal caveats about conclusions drawn from limited data: the margin of error could be quite high. Second, trait developers with monopoly power may have an incentive to share the benefits of technological innovations during the early adoption stage, and then reduce the farmer and consumer share as more farmers adopt the technology. This practice would be limited by the strength of consumer demand, the length of intellectual property right protection and the eventual threat of competition (provided the technology was possible to duplicate economically). Third,

[3] Monsanto recently acquired Asgrow Agronomics and DeKalb Genetics.

pricing decisions may be complicated by the fact that in many of the current cases of biotech innovation, the company involved is also marketing a complementary chemical, as in the case of Monsanto's Roundup Ready soybeans and Roundup Ready herbicide. Companies may maximize revenues by offering the technology at a lower price in order to increase sales of the complementary product.

Distribution of the Costs and Benefits Arising After the Introduction of First-Generation Biotech Varieties and the Subsequent Demand for Non-Biotech Products

The introduction of first-generation biotech varieties and the subsequent segregation of biotech and non-biotech commodities and products may create a group of consumers that are economically worse off than before the introduction of the first-generation biotech technologies. In a competitive market, the introduction of first-generation biotech varieties and the demand for non-biotech products will result in a differentiated market with two different prices for two different goods. The price for biotech commodities in this differentiated market will be lower than the initial market price, and the price for non-biotech commodities will be higher than the initial market price. The price drop creates gains for those consumers who are indifferent between biotech and non-biotech products, but the price hike creates economic losses for consumers who prefer non-biotech. As a result, though the market mechanism may be successful in the sense that consumer demand drives product differentiation, the process creates distinct groups of winners and losers. While true in many cases of product innovation and differentiation, this result nevertheless may indicate a role for government in redressing the distribution of losses. If the losses to consumers who prefer non-biotech commodities outweigh the gains to those who are indifferent, then government involvement in the market may be warranted. However, even if net consumer benefits are positive, the costs imposed on those consumers who prefer non-biotech products may be perceived as unfair. A government could potentially decide to play a role in redistributing these costs.

Another sort of distributional problem may occur with respect to the way the benefits of technological innovation are distributed between society and private entities. The system of intellectual property rights (IPR) is intended to solve the market failure that results when innovators who wish to develop commercial products are deterred from the supporting research because they cannot appropriate a sufficient proportion of the returns from their research. In the United States, IPR have been applied to agricultural machinery for a long time, and for agricultural chemicals such as fertilizers for over 140 years. Intellectual property protection for living organisms such as plants or animals, however, is a more recent phenomenon. The Plant Patent Act of 1930 established a special category of patents for asexually reproduced plants. The Plant Variety Protection Act of 1970 offered relatively weak intellectual property protection to plant breeders. In 1980 the U.S. Supreme Court ruled that living material was patentable. The Patent and Trademark Office (PTO) concluded in 1985 that patents could be issued for seeds, plants, plant parts, plant genes, and tissue cultures. In 1987 the PTO extended similar patent protection to animals.

Safe, commercially successful biotech innovations are very costly to develop, but relatively inexpensive to reproduce, particularly in the case of self-pollinating crop varieties such as soybeans. Genetically modified plant material can often be resold or regrown from seed. Strong IPR ensures that firms can capture the returns to their investment in development. The strengthening of IPR in plants has clearly been one of the major factors that has stimulated much greater private sector investment in agricultural genetics in the 1980s and 1990s. In the 1990s, the use of standard utility patents in plants increased rapidly, at the same time that the use of plant varietal protection certificates declined. Plant utility patents of all types increased from 15 in 1986 to 40 in 1992 to 98 in 1994 to 483 in 1998. Roughly 80 percent of the plant-related patents granted are held by the private sector.

Utility patents are by far the most dominant form of IPR protection used for biotechnology. While the patent data have not been fully analyzed, field test data suggest that the most commonly issued patents concern herbicide tolerance, insect resistance, product quality, and virus resistance, in that order. Utility patents that concern corn far outnumber those granted for other crops with patents such as potatoes, soybeans, tomatoes, or cotton. This suggests that the trade secrets protection offered by hybrid crops reinforces the further protection available through utility patents. Though fewer patents have been issued relevant to soybeans, a self-pollinated crop, than to corn, a hybrid crop, far more patents have been issued in soybeans than in wheat, another self-pollinated crop. Thus both patent protection and technical protection through hybridization are important in encouraging private research investment, but IPR is not the sole factor driving this investment.

In an IPR "agreement," society agrees to grant the innovator protection against unauthorized use by other individuals or companies for a limited period of time. Through this agreement, society essentially agrees to let the innovator set the pace and mode of product innovation and to determine the distribution of economic surplus (given the limits of consumer demand). To provide the greatest benefits to society as a whole, IPR must strike a balance between the social benefits from new innovations, and the losses due to the monopoly power granted the innovator. Successful IPR should encourage innovation without unduly restricting the free flow of scientific knowledge. And, successful IPR should not result in the demise of a potentially beneficial innovation if the original innovators are unsuccessful in the marketplace. It is too early to determine whether IPR for food biotechnology have been too weak or too strong in enhancing social benefits.

VI. Potential Areas for Government Involvement

We have organized our discussion of potential government roles for addressing the problems arising with market differentiation according to the general policy objective. Note that these are hypothetical roles and do not represent actual government policy proposals. First we examine options designed to reduce or eliminate the need for segregation altogether. Second, we examine those options designed to reduce or redistribute risks associated with non-biotech or biotech production and marketing. Third, we examine those options targeted to redistributing the costs and benefits of biotech production and subsequent market differentiation.

Options to Eliminate or Reduce the Need for Segregation

Government involvement could reflect a strategy to either eliminate or reduce the need for market differentiation. If government policies could eliminate the need for differentiation of biotech and non-biotech products, then all the costs and risks associated with segregation would be eliminated. For example, if policy could confine non-biotech demand to a small share of the market, then production of non-biotech products could be isolated in niche marketing systems and segregation would not be necessary throughout the general marketing system. Here, we examine two hypothetical options to eliminate or reduce the need for segregation: a prohibition on biotech or non- biotech labeling; and government-sponsored education on biotechnology.

Prohibit Biotech or Non-Biotech Labeling. If the market were simply not allowed to identify biotech or non-biotech products then the need for segregation would be eliminated. FDA requires labeling if a food differs significantly from its conventional counterpart. This has not been the case for most genetically modified foods. Nevertheless, the movement for biotech labeling is being driven by foreign and domestic consumer preferences, and these preferences have already provided some producers with the incentives to segregate and label non-

biotech commodities. If government regulations were enacted to prohibit product identification and differentiation, consumers who prefer non-biotech commodities would be made worse off, as would producers supplying this market.

Consumer Education. A number of observers have suggested that the government should become involved in educating both domestic and foreign consumers about the safety of genetically modified food. There are, however, a number of reasons this approach may not be totally successful.

First, it is unclear that domestic consumers would change their consumption behavior in response to government-sponsored education efforts. In the United States, both marketplace behavior and survey results indicate that the majority of consumers are typically not very concerned with how their food is produced. These consumers have demonstrated very little awareness of conventional production methods, let alone biotech methods. A government-financed education campaign designed to reassure consumer that their genetically engineered food is safe is unlikely therefore to have much impact on consumer food choices.

Second, a U.S. government-sponsored education efforts in Europe would face particular challenges. In Europe, consumer trust in government-supplied food safety information is likely to be low for a number of reasons, including the fact that the United Kingdom was slow to admit a problem with the new-variant Creutzfeldt-Jakob disease derived from beef, and the fact that Belgium was so slow to admit that food was contaminated with dioxin. Survey research supports the view that public trust in regulatory authorities is higher in the United States than in Europe, and it is unlikely that a U.S. government program to change consumer attitudes in Europe could be effective.

Third, greater knowledge of biotechnology need not lead to greater acceptance of these technologies. For example, European consumers have had a much keener awareness of biotechnology than American consumers, but this has not translated into a greater acceptance of genetically engineered food. Numerous surveys reveal a high degree of confusion among Americans about what the words "biotechnology" and "genetic engineering" mean, especially when applied to foods. Nevertheless, concern about the safety of genetically engineered food is low in the United States. In contrast, survey evidence suggests that many Europeans have some basic understanding of "genetic engineering;" nevertheless, many European consumers express concerns about biotechnology.

Fourth, survey results have shown that opposition to the use of biotechnology in food production is often driven by ethical considerations rather than by calculations of the risks and benefits of biotechnology. Because government-sponsored education programs could address only risk concerns, they would necessarily be poorly targeted.

Possible Options to Reduce or Redistribute the Economic Risk Associated with Biotech or Non-Biotech Production

We discuss five hypothetical approaches to redistributing the economic risk associated with non-biotech production: voluntary labeling, government-established tolerance levels for non-biotech corn and soybeans, testing standards, increased storage capacity, and more detailed price and production data distinguishing between biotech and non-biotech commodities.

Voluntary Labeling. To include voluntary labeling as an option for government involvement in market differentiation may appear rather odd since market-driven voluntary labeling is occurring both in the United States and in foreign markets. However, the labeling movement is still in its early stages in the United States and a number of decisions about how voluntary labeling will proceed need to be worked out. Most important, tolerance levels and testing norms must be established. In the United States, labels are used to convey a wide variety of product information of value to consumers and there are a number of different ways to establish standards and certification requirements. Some labels rely on government-established standards and certification, for example, nutrition labeling. Others rely on a combination of government standards and private certification, for example the "Qualified Through Verification" program for fresh cut vegetables (similar to the hazard analysis and critical control point system for meat and poultry). Other labels rely on purely private entities to set and enforce standards, as with kosher labeling. Voluntary labels could also be coupled with a government-stipulated disclaimer assuring consumers about the general safety of any food offered for sale. This is the approach the United States has used with respect to bovine growth hormones and beef. For example, the label on a Ben and Jerry's carton of ice cream states that they oppose the use of recombinant bovine growth hormones, but this declaration is conditioned by the statement that the "FDA has said no significant difference has been shown and no test can now distinguish between milk from rBGH treated cows and untreated cows."

A government role in establishing standards and certification requirements is most clear cut when producers do not have the incentive to supply information on those product characteristics that may be important to consumers. For biotech commodities and products, producers of first-generation biotech varieties do not have the incentive to provide information on biotech status; in fact they probably have the incentive to remain indistinguishable from non-biotech commodities and products. However, non-biotech producers do have incentives, in the form of price premia, to segregate and identify their products. The government could play a beneficial role in this process if the market mechanism proved too slow and costly. The next two options examine a potential role for government involvement in setting tolerance levels for non-biotech commodities and providing testing standards.

Tolerance Levels. It has been argued that the government could facilitate the development of a non-biotech market by setting tolerance levels for biotech content in non- biotech products. Just as grading standards are useful for specifying quality in futures contracts, storage contracts (warehouse receipts), and sales contracts between buyers and sellers, so too, it is argued, biotech standards or tolerance levels may be useful for smooth marketing of non- biotech products. Because the *U.S. Standards for Grain* establish grading standards and procedures, one could argue that the government should also establish standards for biotech content. AMS and GIPSA routinely set standards for a diverse set of agricultural product characteristics, and many standards are set to satisfy market participants' information requirements.

Advisability of government involvement in standard setting seems to hinge on two questions. First, are government agencies the best judge of the correct level for biotech tolerances? Tolerance levels can be set at any level. To be effective, a standard must reflect both consumer preferences and the testing capabilities of current technology. The market, through constant interaction between producers and consumers may be a better gauge of both consumer preferences and of cost-effective technologies. The second question is whether government-set tolerances are sufficiently flexible. The Delaney Clause flatly prohibited any food additive found to induce cancer in human or animals, no matter how small the risk. While the Delaney Clause may not have been significant when it became law in the 1950s, pesticide detection sensitivity increased several orders of magnitude

afterward. The provision codified into law the idea that the most sensitive testing methods available would be required. Consequently, as testing methods became more sensitive, some products once considered safe no longer received approval. For a time, the Environmental Protection Agency tried to substitute a *de minimus* standard, but litigation in the 1990s resulted in a demand for a literal interpretation. A major change in pesticide legislation was required to mitigate the problems the Delaney Clause raised for regulators, consumers, and the agricultural sector. Biotech detection testing is at an early stage of development and any standards set using current technologies would likely become obsolete fairly quickly, causing the standards themselves to become obsolete.

It is sometimes argued that the government should establish tolerance levels so that unrealistic levels are not established. However, if the government sets lenient tolerance levels in order to ease stringent segregation requirements, these tolerance levels could end up being completely meaningless. Buyers and sellers ultimately decide on the tolerance level they are willing to abide by and government levels that are too lenient may not be valued by the marketplace. An alternative to government-established tolerance levels is for market participants to contractually specify tolerance requirements, and to allow those requirements to change with the biotech detection technology and consumer demand.

Certification and Verification of Non-Biotech status. Currently, a problem with the implementation of biotech testing procedures is that there is no standardization of reference material, sampling methods, extraction procedures, etc., which can lead to variability in results. The mission of the Grain Inspection, Packers and Stockyards Administration (GIPSA) is to facilitate the marketing of livestock, poultry, meat, cereals, oilseeds, and related agricultural products and promote fair and competitive trading practices for the overall benefit of consumers and American agriculture. In accordance with its authority under the United States Grain Standards Act and Agricultural Marketing Act of 1946, GIPSA will establish a reference laboratory in Kansas City, MO, to evaluate and verify the validity of analytical techniques applied to the detection of genetically enhanced traits in grains and grain products. These services, which are expected to be available for the 2000 crop year, will help standardize the testing of genetically enhanced grains throughout the commercial market. The credibility of this reference facility will depend largely on the willingness of the biotechnology firms to cooperate with GIPSA by providing the following information and/or materials:

- Reference materials
    - Supplies of grain with a specific expressed trait to be used in evaluating analytical tests (ELISA microwells and dipsticks)
    - Sufficient quantities of the expressed protein for the development and/or evaluation of alternative testing procedures
- Genetic sequences for the evaluation of DNA-based analytical techniques
- Specific information on analytical techniques developed or used by the biotechnology firm (PCR, ELISA, other future techniques)

Much of this information is proprietary, and therefore, confidentiality agreements will be established to protect the intellectual property rights of all parties involved. Appropriate security systems will be installed in the reference facility to ensure the protection and safekeeping of all sensitive information.

It should be noted that, like United Laboratories (UL) for electrical appliances or Oregon Tilth for organic crops, private entities are also capable of establishing recognized standards and testing procedures. In fact a private entity has already certified two of the biotech detection methods. Both the ELISA test and PCR have been validated as methods for biotech detection by the Joint Research Council in the EU. As far as the EU market is concerned, private accreditation, particularly when the private group is a recognized medical or environmental group, may lend more credence to the process than government accreditation.

Increase Storage Capabilities. Even in the absence of industry efforts to segregate biotech and non-biotech crops, the grain and oilseed storage system has been strained. The 1996 Farm Bill made crop production market oriented and removed program acreage restraints. Acres planted to primary crops increased and yields for some crops have been record or near record high. Record crops and large beginning stocks of grains and oilseeds have strained storage capacity, even in the absence of biotech segregation. Biotech segregation would likely exacerbate these storage problems. Over time, the industry and farmers will invest in additional storage and handling capacity. Nonetheless, to provide farmers with greater marketing flexibility, Secretary Glickman has asked for more Federal funding for investing in onfarm storage facilities and such loans would also help farmers build bins for segregating grains.

Market Information. One type of service the government can provide to support market flexibility in the face of diversification and differentiation is information on market statistics that mirror the development of new varieties and differentiated markets. For biotech and non- biotech commodities, information on price, acreage, and potential markets would help farmers and others make informed decisions (although proliferation of products and contracting systems may make it difficult for the government to provide accurate statistics on all varieties).

Currently, the National Agricultural Statistics Service (NASS) surveys corn, cotton, and soybean farmers in selected States on their use of herbicide- and/or pest-resistant seed varieties (a practice begun in 1998). Results for the 1998 and 1999 crops were first published in the October 1999 *Crop Production* report. NASS currently plans to update the data series each year in the October *Crop Production* report. The data are drawn from objective yield surveys conducted by NASS. Randomly selected plots are visited monthly from August through harvest to obtain specific counts and measurements. Detailed information concerning the selected fields, including use of herbicide- and/or disease-resistant varieties, is obtained during an initial producer interview.

NASS also publishes a *Prospective Plantings* report in late March that reflects a survey of farmers' planting intentions during the first two weeks of March and a June *Acreage* report that reflects a survey of farmers' actual planted acreage taken during the first two weeks of June. Because these reports are based all, or in part, on planting intentions, they can vary widely from the acreage estimate reported in the October *Crop Production* report. The March 2000 *Prospective Plantings* report provides information on biotech and non-biotech planting intentions. The June 2000 *Acreage* report will also include information on biotech and non-biotech plantings.

Government Farm Support Programs. Whether farmers plant biotech or non-biotech varieties, they are covered by a variety of government farm support programs. However, market differentiation for biotech and non-biotech commodities in the U.S. marketing system has not been incorporated into USDA farm programs. Here we look at two programs, the nonrecourse marketing program and crop insurance.

USDA operates nonrecourse marketing loan programs for grains and oilseeds. Producers have the option of defaulting on the loan and forfeiting the commodity. The marketing loan provision permits a producer who has placed grain or oilseeds under loan to repay the loan at less than the original loan rate, if the local market price is lower. The actual repayment rate would be the USDA-determined posted county price (PCP) which approximates the local market price. A producer who has not put his crop under loan may elect to take a loan deficiency payment (LDP) equal to the difference between the PCP and the loan rate and forgo placing the crop under loan. A producer will repay his loan at the original rate when market prices move higher than the original loan rate.

USDA commodity loan programs do not distinguish between biotech and non-biotech varieties. If producers are finding it difficult to market biotech varieties or find the market is discounting biotech varieties, use of the loan program is an option. USDA will be determining PCP's based on the mix of biotech and non-biotech. However, if the market determines that biotech varieties have lower value, and the mix of varieties used to set the PCP is more heavily non-biotech, then the PCP will tend to be higher than if there were no sorting out of biotech varieties to the loan program. The result is that repayment rates will be higher and LDP's will be lower. These effects have not been estimated.

Crop insurance contracts do not differentiate by biotech status. This may change for several reasons. First, if biotech and non-biotech varieties display significant differences in production risk, e.g., drought resistance, then crop insurers will respond with suitable policies and premiums. Second, if biotech and non-biotech varieties have different market values, the price selection options will adjust to recognize this. There appear to be no impediments to developing suitable crop insurance products to accommodate biotech varieties.

Options to Redistribute the Costs and Benefits of Biotech Production and Subsequent Market Differentiation

Here we examine two hypothetical options targeted to redistributing the costs and benefits of biotech production and subsequent market differentiation: mandatory labeling of biotech commodities and products; and public research and development.

Mandatory Labeling of Biotechnology. Mandatory labeling of first-generation biotech varieties has been suggested as one means of redistributing some of the costs of market differentiation back to the biotech producers. However, unless mandatory labeling schemes are coupled with high consumer demand for non-biotech products and strict segregation requirements, mandatory labeling will probably be unsuccessful in transferring the costs and responsibility of segregation from non-biotech producers and consumers to biotech producers and consumers. Because their consumers are indifferent between biotech and non- biotech products, biotech producers do not have the incentive to segregate, in fact they probably have the incentive to remain indistinguishable from non-biotech commodities and products. Even if these producers label their products with "may contain biotech material" or "does contain biotech material," it will still be left to non-biotech producers to certify that their products are indeed non-biotech.

Public Research and Development. Surveys show that the majority of Americans trust U.S. regulatory agencies. In a recent survey published in *Science*, 90 percent of the respondents said that they would trust statements made by the USDA concerning the safety of biotechnology (84 percent for FDA). This, combined

with the observation that trust in regulatory agencies in Europe is substantially lower (only about 4 percent said they trusted statements made by national public bodies concerning genetically modified crops), may help to explain why public concerns regarding biotech foods are greater in Europe than the United States. Government initiatives may be well warranted, then, to ensure that the regulatory capacity, and, therefore, its credibility with the public, continues to advance along with advances in biotechnology. For this reason, Secretary Glickman called recently for an independent scientific review, to be conducted by the National Academy of Sciences, of USDA's biotechnology approval process. Additionally, the USDA Agricultural Research Service is now designing a system for review of new research projects, which will help determine if additional public sector research is necessary to fill knowledge gaps related to risk assessment of products that result from agricultural biotechnology research. This study will also include discussions with key contacts in other research and regulatory agencies to define the appropriate role and structure for future ARS risk assessment research related to biotechnology.

Vll. Conclusion

Domestic producers are responding to the opportunities and economic risks arising with differentiated markets for biotech and non-biotech commodities and products. Some are benefiting through the lower production costs associated with first-generation biotech varieties, while others are tailoring their production to benefit from the emerging markets (and price premia) for non-biotech products. In this respect, differentiation in the markets for biotech and non-biotech commodities is an extension of a small but significant trend away from the marketing of general bulk commodities toward differentiated commodity marketing. Small segments of the corn and soybean markets were becoming increasingly differentiated long before the introduction of biotech varieties, with farmers, handlers and processors specializing in commodities with high-valued attributes. Increased demand for specific quality attributes on the part of processors and increased availability of specialty crops (including eventual introduction of second-generation biotech varieties – those with output traits) will continue to reinforce this trend.

An important service the government can provide to support market flexibility in the face of diversification and differentiation is information on market statistics that mirror the development of new varieties and differentiated markets (although proliferation of products and contracting systems may make it difficult for the government to provide accurate statistics on all varieties). For biotech and non-biotech commodities, information on price, acreage, and potential markets could help farmers and others make informed decisions. Another important role for government with respect to agricultural biotechnology is to ensure that the government's regulatory capacity, and therefore, its credibility with the public, continues to advance along with advances in biotechnology. For this reason, further investments in public research and development, or reallocation of the research and development portfolio may be warranted.